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Short Report: Treatment

Potential of electric bicycles to improve the health of people with Type 2 diabetes: a feasibility study

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Abstract

Aim To explore in a feasibility study whether ‘e-cycling’ was acceptable to, and could potentially improve the health of, people with Type 2 diabetes.

Methods Twenty people with Type 2 diabetes were recruited and provided with an electric bicycle for 20 weeks. Participants completed a submaximal fitness test at baseline and follow-up to measure predicted maximal aerobic power, and semi-structured interviews were conducted to assess the acceptability of using an electric bicycle. Participants wore a heart rate monitor and a Global Positioning System (GPS) receiver in the first week of electric bicycle use to measure their heart-rate during e-cycling.

Results Eighteen participants completed the study, cycling a median (interquartile range) of 21.4 (5.5–37.7) km per week. Predicted maximal aerobic power increased by 10.9%. Heart rate during electric bicycle journeys was 74.7% of maximum, compared with 64.3% of maximum when walking. Participants used the electric bicycles for commuting, shopping and recreation, and expressed how the electric bicycle helped them to overcome barriers to active travel/cycling, such as hills. Fourteen participants purchased an electric bicycle on study completion.

Conclusions There was evidence that e-cycling was acceptable, could increase fitness and elicited a heart rate that may lead to improvements in cardiometabolic risk factors in this population. Electric bicycles have potential as a health-improving intervention in people with Type 2 diabetes.

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Introduction

Lifestyle change, including weight loss, improves HbA_{1c} concentration and other cardiovascular risk factors in people with Type 2 diabetes [1–3], and can achieve remission to a non-diabetic state, with remission closely related to the degree of weight loss [3]. As well as weight loss, increasing physical activity is a target of such interventions, but success in changing activity behaviour is often limited [1,2] and any changes are rarely maintained at initial levels [3]. Physical activity has independent benefits for health and is important in the maintenance of weight loss; there is a need, therefore, to develop acceptable and sustainable physical activity interventions for people with Type 2 diabetes. This is

challenging, however, because this population is less active than those without diabetes [4] and responds poorly to advice to increase physical activity [5].

Active commuting is associated with higher physical activity [6], weight loss/maintenance [7] and improved cardiovascular health in the general population [8], and people with Type 2 diabetes who actively commute are substantially more active than vehicle users [9]. Prospective studies comparing the benefits of walking vs cycling suggest that cycling may provide greater health benefits than walking in healthy individuals [10], potentially through the higher intensity of cycling which leads to increased fitness [11]; however, there are a number of barriers, including hilly routes and perceived effort, which are likely to discourage people with Type 2 diabetes from cycling.

Electric bicycles (e-bikes) provide graded assistance to the rider, helping to overcome such barriers, and are increasingly popular, particularly amongst middle-aged to older adults [12]. In healthy individuals, riding an e-bike has been shown

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What's new?

- No studies to date have explored the utility of electric bicycle (e-bike) use in people with Type 2 diabetes.
- 'E-cycling' elicits a higher heart rate than walking in people with Type 2 diabetes.
- Preliminary evidence suggests that e-cycling may be effective in increasing fitness in people with Type 2 diabetes.
- E-cycling was popular, with two-thirds of participants purchasing an e-bike at the end of the study.
- As people with Type 2 diabetes are a population in which advice to increase physical activity is often ineffective, e-cycling has good potential as a health-improving intervention.

to provide physical activity of at least moderate intensity [>3 metabolic equivalents (METs); heart rate $>65\%$] and generate improvements in fitness and cardiometabolic risk factors [13–15]; however, to date, the acceptability/feasibility of 'e-cycling' for people with Type 2 diabetes, or benefits to health are unknown.

The aim of the present feasibility study was to determine whether e-cycling was acceptable to people with Type 2 diabetes, to determine whether an e-bike would be used if provided, to explore outcome measures for future studies and to describe the experience of using an e-bike to inform intervention development.

Participants and methods

Ninety-nine people from an observational study of sedentary behaviour in adults with newly diagnosed Type 2 diabetes

[$\text{HbA}_{1c} >48$ mmol/mol ($>6.5\%$)] were invited to participate, with 28 expressing interest. A total of 20 people participated between May and October 2016, of whom 18 completed the study (Table 1). Ethical approval was granted by the University of Bristol, Faculty of Health Sciences.

Participants provided their height, weight and clinical history. Aerobic fitness [predicted maximal aerobic power (W)] was measured in a sub-maximal test [16] on an upright, electronically braked cycle ergometer (Schiller ERG911 BP/LS; Schiller Ltd., Staines, UK). Participants warmed up by cycling for up to 4 min at a low load, and then cycled at a cadence of ~ 60 revolutions/min for three progressive workloads, each for 4 min, before cooling down at a light load for 30–60 s. Workloads were selected so that heart rate in the final stage was ~ 70 – 85% of predicted maximal heart rate for age (HR_{\max}). Heart rate was measured at rest and at the end of the third minute of each workload. Heart rate during each of the three workloads, workload [Watts (W)], and HR_{\max} were used for estimation of maximal aerobic power (Table 2).

After measurement of baseline variables, participants individually met a cycle instructor (Life Cycle UK; www.lifecycleuk.org.uk) to familiarize them with the e-bike and to provide cycle training on local roads, including guidance on safe riding practices. Participants were then provided with an e-bike, helmet, gloves, reflective bib, lock and panniers to use for 20 weeks. Support was provided for any mechanical problems encountered by participants. The built-in e-bike odometer values were recorded at the start and end of the loan period to measure total distance cycled.

In the first week of cycle usage participants wore a combined heart rate and accelerometer (ActiHeart; CamN-tech, Cambridge, UK) and a Global Positioning System (GPS) receiver (QStarz BT1000X; QStarz International Co. Ltd, Taipei, Taiwan), recording data every 15 s. Data were merged by timestamp and visualized in a Geographic Information System (ArcMap) to identify journeys by e-bike

Table 1 Participant characteristics

	Men ($n=11$)	Women ($n=7$)	All ($n=18$)
Baseline characteristics			
Age, years	57.5 (9.3)	59.1 (5.5)	58.1 (7.9)
Height, m	1.78 (0.07)	1.61 (0.06)	1.72 (0.11)
Weight, kg	93.5 (15.6)	81.4 (10.0)	88.8 (14.7)
BMI, kg/m^2	29.6 (5.3)	31.2 (2.5)	30.2 (4.4)
Overweight, n (%)	7 (63.6)	2 (28.6)	9 (50.0)
Obese n (%)	4 (36.4)	5 (71.4)	9 (50.0)
Ethnicity: white, n (%)	10 (90.9)	7 (100)	17 (94.4)
Current smoker, n (%)	1 (9.1)	2 (28.6)	3 (16.7)
Employed, n (%)	7 (63.6)	3 (42.9)	10 (55.6)
Retired/not working, n (%)	4 (36.4)	4 (57.1)	8 (44.4)
Duration of diabetes, years	2.2 (0.7)	2.4 (0.6)	2.2 (0.6)
Maximal predicted aerobic power (W_{\max}); n	193.3 (37.9); 10	137.2 (28.2); 5	174.6 (43.6); 15

HR_{\max} , predicted maximal heart rate for age; W_{\max} , maximal predicted aerobic power in Watts.

$\text{W}_{\max} = \text{workload}_3 + \{[\text{HR}_{\max} - \text{HR}_3] * [\text{workload}_3 - \{(\text{workload}_1 + \text{workload}_2)/2\}]/[\text{HR}_3 - \{(\text{HR}_1 + \text{HR}_2)/2\}]\}$.

Data are mean (SD) unless stated otherwise.

Table 2 Study outcomes

	Men (<i>n</i> =11)	Women (<i>n</i> =7)	All (<i>n</i> =18)
Median (IQR) total distance cycled, km	456.0 (379.0–1395.0)	111.0 (73.0–252.0)	383.5 (103.0–738.3)
Median (IQR) weekly distance cycled, km	23.1 (21.3–72.9)	6.2 (5.5–14.9)	21.4 (5.5–37.7)
Mean (SD) heart rate during e-cycling journeys, bpm	121.2 (17.2)	132.6 (18.9)	125.2 (18.1)
Mean (SD) heart rate during walking journeys, bpm	103.2 (14.1)	116.5 (16.9)	107.6 (15.8)
Mean (95% CI) change in maximal predicted aerobic power, W	24.0 (–11.7,59.7)	9.1 (–8.17,26.4)	19.1 (–3.9,42.0)

bpm, beats per min; IQR, interquartile range; W, Watts.

or foot [6]. For each journey, the mean heart rate and percentage of HR_{max} were calculated.

Baseline measures were repeated during the final week of e-bike use, and semi-structured interviews were conducted to explore experiences of using the e-bike.

Results

Participants cycled ~21 km per week, with men cycling four times further than women (Table 2). One collision with a vehicle occurred, resulting in minor injury. Overall, values for predicted maximal aerobic power were 10.9% higher at follow-up, with 12 of 15 participants recording improved values.

Participants provided 49.2 h of combined heart rate and GPS data, including a mean (SD) of 4.5 (3.3) e-bike journeys [mean (SD) distance 7.5 (4.2) km, mean (SD) duration 26.6 (12.6) min] and 3.7 (2.4) walking journeys [mean (SD) distance 1.0 (1.1) km, mean (SD) duration 16.0 (17.2) min]. Heart rate during e-bike journeys was 74.7% of maximum, compared with 64.3% of maximum when walking.

Interviews found that e-bikes played an important role in removing barriers to active travel/cycling and participants used them for commuting, shopping and recreation. An advantage was to be able to travel to destinations without perspiring excessively. The e-bikes enabled many participants to enjoy being physically active outdoors and to cycle with partners or friends. The cycle trainers were seen to be important in developing confidence. Most participants were reluctant to return their e-bikes at the end of the intervention period, and 14 purchased the e-bike that they had used or an alternative brand.

Discussion

The primary aims of the present feasibility study were to determine whether e-cycling was acceptable to a sample of people with Type 2 diabetes, and whether an e-bike would be used if provided. Of 99 people with Type 2 diabetes invited, 20 agreed to participate in the study, suggesting that the concept was acceptable to a reasonable proportion of this population. One participant consented but thereafter did not engage with the study, and a second participant withdrew

during the intervention. Of the remainder, all participants used the provided e-bike, with most cycling >15 km per week on average and some cycling substantially further. The e-bikes were used for a range of purposes, and participants were positive about the experience of using them. Men used the e-bikes to a greater extent than women, suggesting that future interventions will need to be tailored to the different requirements of both sexes. One participant had a collision with a motor vehicle, resulting in relatively minor injuries, but subsequently continued to use the e-bike. There is evidence that e-cyclists go faster than conventional cyclists, and that this is associated with higher rates of injury [17]. Any future programme should consider these risks and ensure, as we did in the present study, that e-bike users are appropriately trained and provided with safety equipment to minimize risk.

Although this feasibility study was not powered to determine any differences in maximal power output, most participants recorded higher fitness test results at follow-up, suggesting that e-cycling could be associated with improved fitness in this population. This observation would be consistent with data from healthy adults, where 6 weeks of daily commuting was associated with an increase in maximal power output [18]. In addition, we found that heart rate during e-cycling was within the range sufficient to increase cardiorespiratory fitness and was comparable to experimental studies in younger healthy individuals where e-cycling elicited a heart rate of 67–69% HR_{max} over a flat circuit [15] and 80–84% HR_{max} on an uphill route [14]. Increased fitness through e-cycling may be predictive of improvements in cardiometabolic risk factors [19], with a recent study reporting improved response to an oral glucose tolerance test in healthy individuals [20], suggesting that e-cycling may have potential for improving glucose control in people with Type 2 diabetes.

The present study has some limitations. Three participants could not complete the fitness test, although sub-maximal. Heart rate whilst cycling was measured only in the first week of the study, and may have been influenced by the unfamiliarity of cycling on roads. The GPS receivers were worn by the participants, and may not have been worn/switched on all the time. We cannot be certain, therefore, that we identified all journeys and there is also the possibility that

some slow cycling journeys were mis-classified as walking. A more extended period of GPS recording would be valuable in future studies to describe journeys in more detail and to explore potential displacement of motorized travel.

The limited success in increasing physical activity in randomized controlled trials, and the failure to sustain initial improvements, indicate the need to identify acceptable and sustainable physical activity interventions for people with Type 2 diabetes. The utility, ease and enjoyment of e-cycling for commuting and carrying out other activities of daily living that we describe in the present study suggest that it is a behaviour that could potentially overcome these limitations by becoming embedded in everyday life, and which has potential as a health-improving intervention in people with Type 2 diabetes.

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Competing interests

None declared.

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